CLAIMS

We claim the following:

1. A method of calculating estimated image profiles, comprising the steps of:

providing imaging configuration characteristic data;

performing simulation calculations for various levels of aberration components using the imaging configuration characteristic data;

building response surface functional relations between variables of lens characteristics and an image profile of interest using the simulation calculations; and

evaluating specified aberration values of a lens in relation to the response surface functional relations to provide an estimate of the image profile in a presence of specified aberration(s).

2. The method of claim 1, wherein the image profiles which result as part of the evaluating step are used as measures of relative lens adjustment goodness in an iterative lens adjustment optimization routine.

3. The method of claim 1, wherein the imaging configuration characteristic data includes lens data, illumination data and pattern data.

4. The method of claim 3, wherein:

the illumination data includes at least one of illumination distribution and illumination wavelength,

the lens data includes at least one of lens aberration, numerical aperture, pupil filters and lens configuration; and

the pattern data includes object (reticle pattern) layout.

5. The method of claim 4, wherein the imaging configuration characteristic data further includes at least one of pattern bias characteristic information and lens focus.

6. The method of claim 1, wherein the simulation calculations are executed for various levels of each aberration component.

7. The method of claim 1, further comprising the step of generating a new set of aberration component impact upon image profile fitted coefficients values using the response surface functional relations each time a new set of input aberration components is presented for image profile calculation.

8. The method of claim 1, further comprising the step of generating a new set of aberration components impact upon image profile coefficient values using interpolative methods using the response surface functional relations.

9. The method of claim 1, wherein the response surface functional relations correspond to a sample set of lens characteristics with a final output from application of response surface functional relations being an image profile under the influence of lens aberrations.

10. The method of claim 9, wherein the data configuration characteristic information includes lens characteristics related to variation in single aberration values alone or in combination with one another or with selected items from among the lens characteristics.

11 The method of claim 1, wherein the response surface functional relations are related to a look-up table summarizing the results of interpolating the image profile generated by the simulation calculations of the performing step.

12. the method of claim 11, wherein the look-up table is direct simulation image profile results or of functional coefficients used to calculate the image profile.

13. The method of claim 11, wherein the evaluating step includes determining image profile data points using the look-up table to provide a new image profile associated with specified aberration values.

14. The method of claim 1, wherein the evaluating step includes applying interpolated data of the built response surface functional relations to calculate the image profile for specified aberration values.

15. The method of claim 1, wherein the evaluating step eliminates the need for a full simulation calculation each and every time new specified aberration values are provided and presented for calculation of a new image profile.

16. The method of claim 1, wherein the building steps includes:

providing an order fitting function expressed as:

$$I_{spx}(x) = b_0 + b_1 x + b_2 x^2 + b_3 x^3 + ... + b_n x^n$$

where I_{spx} is aerial image intensity or amplitude at a simulation pixel *(spx)* and x indicates defocus; and

expressing a change of the coefficients $b_0 \ldots b_n$ described by an order fitting function expressed as:

$$b_{i(with\_aberration)} = b_{i(w/o\_aberration)} + \sum_{j=2}^{Zn} \Delta b_i(cj)$$

$$= b_{i(w/o\_aberration)} + \sum_{j=2}^{Zn} \varphi_{0(i,j)} + \varphi_{1(i,j)} c_j + \varphi_{2(i,j)} c_j^{\ 2} + \varphi_{3(i,j)} c_j^{\ 3} + ... + \varphi_{n(i,j)} c_j^{\ n}$$

wherein

$i = 0, 1, 2, 3, ..., n;$

$b_{i(with\ aberration)}$ and $b_{i(w/o\ aberration)}$ represents one of the coefficients $b_0 \ldots b_n$ influenced by lens aberrations and the coefficients $b_0 \ldots b_n$ without aberrations, respectively, and

Δbi indicates the change in coefficients and is expressed by an n^{th} order fitting function of jth Zernike coefficient c_j,

$\varnothing_{0(ij)} \ldots \varnothing_{n(ij)}$ are the coefficients of the fitting function, determined following the performing step of setup simulations of image profile as a function of regularly iterated values of lens aberration.

17. The method of claim 16, wherein the fit coefficients $\varnothing_{0(ij)} \ldots \varnothing_{n(ij)}$ are generated from a single aberration polynomial coefficient or from at least one of multiplication division of one aberration polynomial coefficient by another.

18. The method of claim 16, wherein the coefficients $b_0 \ldots b_n$ are stored for each simulation calculation following their determination via fitting to the simulation calculation of the performing step.

19. The method of claim 16, wherein n=4.

20. The method of claim 16, wherein Zn = 37.

21. The method of claim 1, wherein each different aberration value applied during the performing step leads to one full image simulation calculation.

22. The method of claim 1, wherein the evaluating step provides one output image profile for each one set of specified input aberration values.

23. The method of claim 1, wherein the response surface function relations are built relating any of variables: (i) position within a specified image plane, (ii) intensity or amplitude, (iii) focus, and (iv) all component aberration levels.

24. The method of claim 1, wherein the performing step includes the steps of:

defining a simulation pixel as a unit of horizontal or vertical, position into which an aerial image is divided;

calculating aerial image amplitude or intensity on each simulation pixel; and

executing the calculations at defocus positions to provide image profile data including focus response.

25. The method of claim 1, wherein the evaluating step includes summing an impact from all specified aberration values or combinations of values defined as aberration coefficients for image profile reconstruction.

26. The method of claim 25, wherein the summing step provides an output of intensity or amplitude vs. at least one of position and focus for the specified aberration values which are an arbitrary set of aberration values.

27. The method of claim 1, wherein the evaluating step is performed using a linear equation using fixed functions with coefficients determined in the building step.

28. The method of claim 1, wherein the building and evaluating steps are performed using a sinusoidal fitting functions.

29. The method of claim 28, wherein the sinusoidal fitting functions are encountered when applying a Fourier Transformation or Fast Fourier Transform algorithm intended to estimate a Fourier Transformation process.

30. A method of calculating estimated image profiles, comprising the steps of:

performing simulation calculations for various levels of aberration components using image configuration characteristic data;

building response surface functional relations between variables of the image configuration characteristics and the image profile of interest using the simulation calculations as data input to be fit using:

$$I_{spx}(x) = b_0 + b_1 x + b_2 x^2 + b_3 x^3 + ... + b_n x^n$$

where I_{spx} indicates aerial image intensity or amplitude at a simulation pixel *(spx)* and x indicates defocus; and

expressing a change of the coefficients $b_0 \ldots b_n$ described by an order fitting function as:

$$b_{i(with\_aberration)} = b_{i(w/o\_aberration)} + \sum_{j=2}^{Zn} \Delta b_i(cj)$$

$$= b_{i(w/o\_aberration)} + \sum_{j=2}^{Zn} \varphi_{0(i,j)} + \varphi_{1(i,j)} c_j + \varphi_{2(i,j)} c_j^{\ 2} + \varphi_{3(i,j)} c_j^{\ 3} + ... + \varphi_{n(i,j)} c_j^{\ n}$$

wherein

$b_{i(with\ aberration)}$ and $b_{i(w/o\ aberration)}$ represents the coefficients $b_0 \ldots b_n$ influenced by lens aberrations and the coefficients $b_0 \ldots b_n$ without aberrations, respectively,

Δbi indicates the change in coefficients and it is expressed by an nth order fitting function of *j*th Zernike coefficient c_j; and

$\varnothing_{0(ij)} \ldots \varnothing_{n(ij)}$ are the coefficients of the fitting function; and

summing an impact from at least one of all new specified aberration coefficients and combinations of aberration coefficients from the built response surface functional relations to provide lens adjustment data.

31. The method of claim 30, wherein the imaging configuration includes lens data, illumination data and pattern data.

32. The method of claim 30, wherein:

the illumination data includes at least one of illumination distribution and illumination wavelength;

the lens data includes at least one of lens aberration, numerical aperture, pupil filters and lens configuration; and

the pattern data includes object (reticle pattern) layout.

33. The method of claim 30, wherein the simulation calculations are provided for various levels of each aberration coefficient.

34. The method of claim 30, further comprising the step of generating a new set of aberration component values using the response surface functional relations each time a new lens adjustment is considered.

35. The method of claim 30, wherein the summing step includes interpolating data points of data calculated by the simulation calculations to provide a new image profile associated with the new specified aberration coefficients.

36. The method of claim 30, wherein the coefficients $b_0 \ldots b_n$ are stored for each simulation calculation.

37 The method of claim 30, further comprising the steps of:

defining a simulation pixel as a unit of horizontal or vertical position into which aerial image is divided;

calculating aerial image intensity or amplitude for each simulation pixel; and

executing the image simulation calculations at defocus positions to provide image profile response to focus data.

38. The method of claim 30, wherein the response surface function relations are built between any of variables: (i) position, (ii) intensity or amplitude, (iii) focus, and (iv) all component aberration levels.

39. The method of claim 30, wherein the summing step provides an output of intensity or amplitude vs. at least one of position and focus for any arbitrary set of aberration values.

40. The method of claim 30, wherein n=4.

41. The method of claim 30, wherein Zn=37.

42. An exposure apparatus, comprising:

an illumination system that projects radiant energy through a mask pattern on a reticle R that is supported by and scanned using a wafer positioning stage;

at least one linear motor that positions the wafer positioning stage;

a system for providing optimal image profiling, including:

means for providing image configuration characteristic data;

means for performing simulation calculations for various levels of aberration components using the image configuration characteristic data;

means for building response surface functional relations between variables of lens characteristics associated with the image configuration characteristic data using the simulation calculations; and

means for evaluating specified aberration values of a lens in relation to the response surface functional relations to provide image profile estimates for the specified aberration values.

43. The apparatus of claim 42, further comprising means for applying the aberrated image profile estimates in an optimization calculation method which judges image profile information against defined criteria as part of a lens adjustment optimization calculation

44. A device manufactured with the exposure apparatus of claim 42.

45. A wafer on which an image has been formed by the exposure apparatus of claim 42.

46. A system for providing optimal image profiles through the optimization of specified aberration components, according to their associated impact upon image profile, comprising:

means for performing simulation calculations for various levels of aberration components using characteristic data;

means for building response surface functional relations between variables of lens characteristics using the simulation calculations;

means for evaluating specified aberration values of a lens in relation to the response surface functional relations to provide image profile estimates for the specified aberration values; and

means for applying the aberrated image profile estimates in an optimization calculation method which judges image profile information against defined criteria as part of a lens adjustment optimization calculation

47. A machine readable medium containing code for adjusting a lens, comprising at least one module for:

performing simulation calculations for various levels of aberration components using characteristic data;

building response surface functional relations between variables of lens characteristics using the simulation calculations; and

evaluating specified aberration values of a lens in relation to the response surface functional relations to provide image profile estimates for the specified aberration values.

48. The machine readable code of claim 47, wherein the at least one module applies the aberrated image profile estimates in an optimization calculation method which judges image profile information against defined criteria as part of a lens adjustment optimization calculation